

Presentation to **39th Annual** Gun/Ammo & Missiles/Rockets Conference

Deconstruction of Fuze Well Guidance Requirements

April 14, 2004

Chris Geswender

cegeswender@raytheon.com

Andy Hinsdale

Andrew_J_Hinsdale@raytheon.com

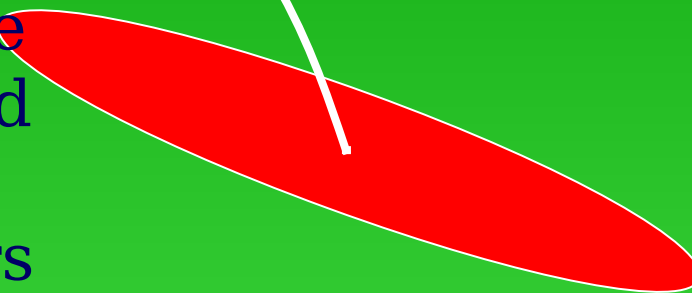
Synthesis of Course Correcting Fuze Design



Corrects major errors incl

- **Inherent Gun laying errors**
- **Muzzle Velocity Variation**
- **MET errors**

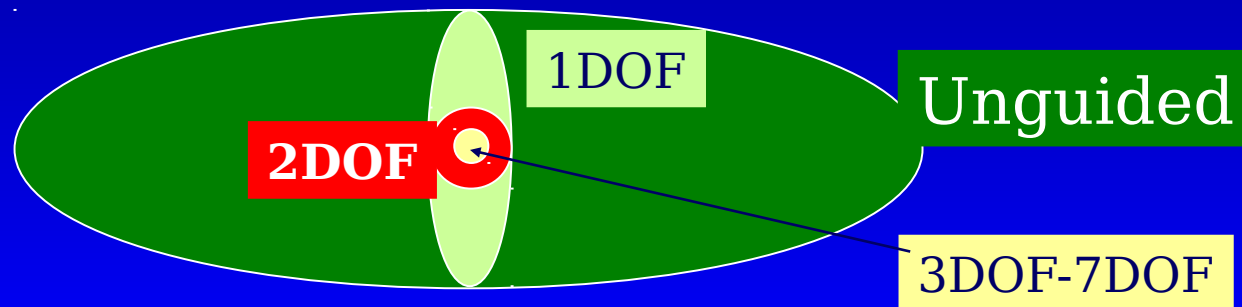
Determine best Solution Space to developing a fuze well based guidance package to provide first shot accuracy < 50 meters



Derived Requirements

Raytheon

- Increase effectiveness and efficiency of cannon artillery
 - **CEP < 50 meters**
 - **Reduce logistics**
 - **Increase OPTEMPO**
- Exploit large existing projectile war stocks
 - **Fuze well implementation**
 - **Reversionary mode (fuze only)**
- Corrector must still be a fuze
 - **Easy to install, program, and be robust to field handling**
 - **Volume for fuze functions**
 - **Must have a reversionary mode**
 - **Cost << \$5000**



Raytheon



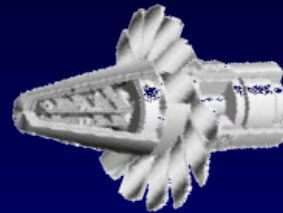
Wide Potential Solution Space

Alternate Concepts	Number of known c
1DOF- Downrange	☒ ☒ ☒ ☒
1DOF- Cross range	☒
2DOF-Decoupled	
Roll stabilized	☒
Roll rate Stabilized	☒ ☒ ☒
2DOF-Body fixed	
Roll Rate/Aerobrake (1+)	☒
Flow disruption	?
HF Fixed canard	☒
HF trailing canard / solenoid	?

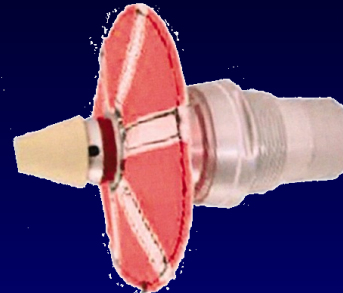
Some Examples

Raytheon

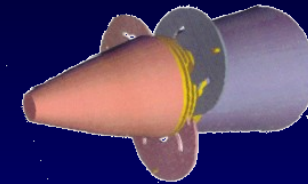
1DOF Range Correctors



STAR



DMS



SPACIDO

2DOF Range/Deflection Correctors

1DOF Deflection Corrector



CMATD



ANSR



NSWC GI



MIT Concepts

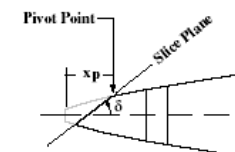


Fig. 1 Geometry of the Sliced Fuze Design

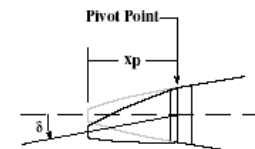
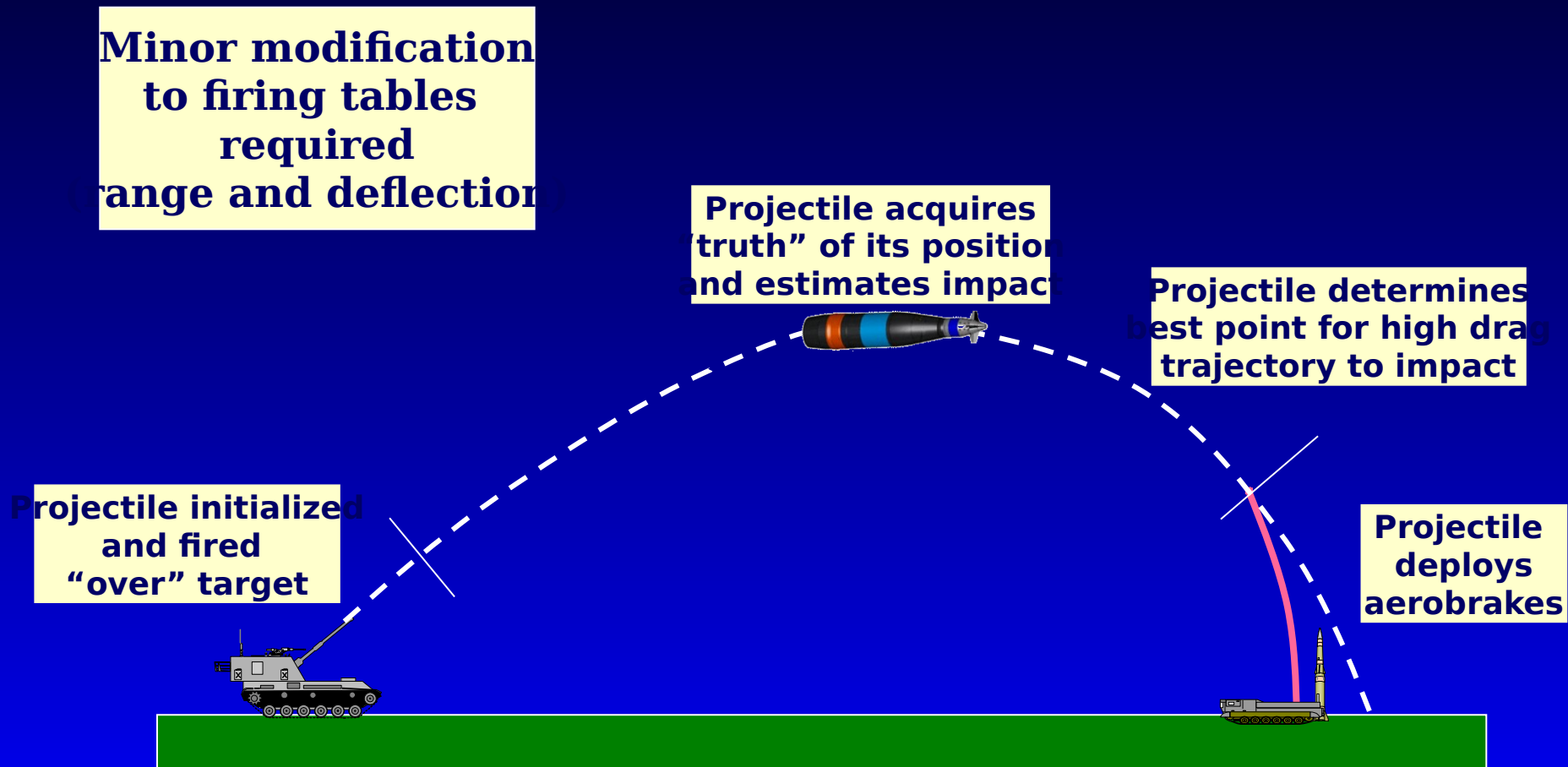


Fig. 2 Geometry of the Bent Fuze Design

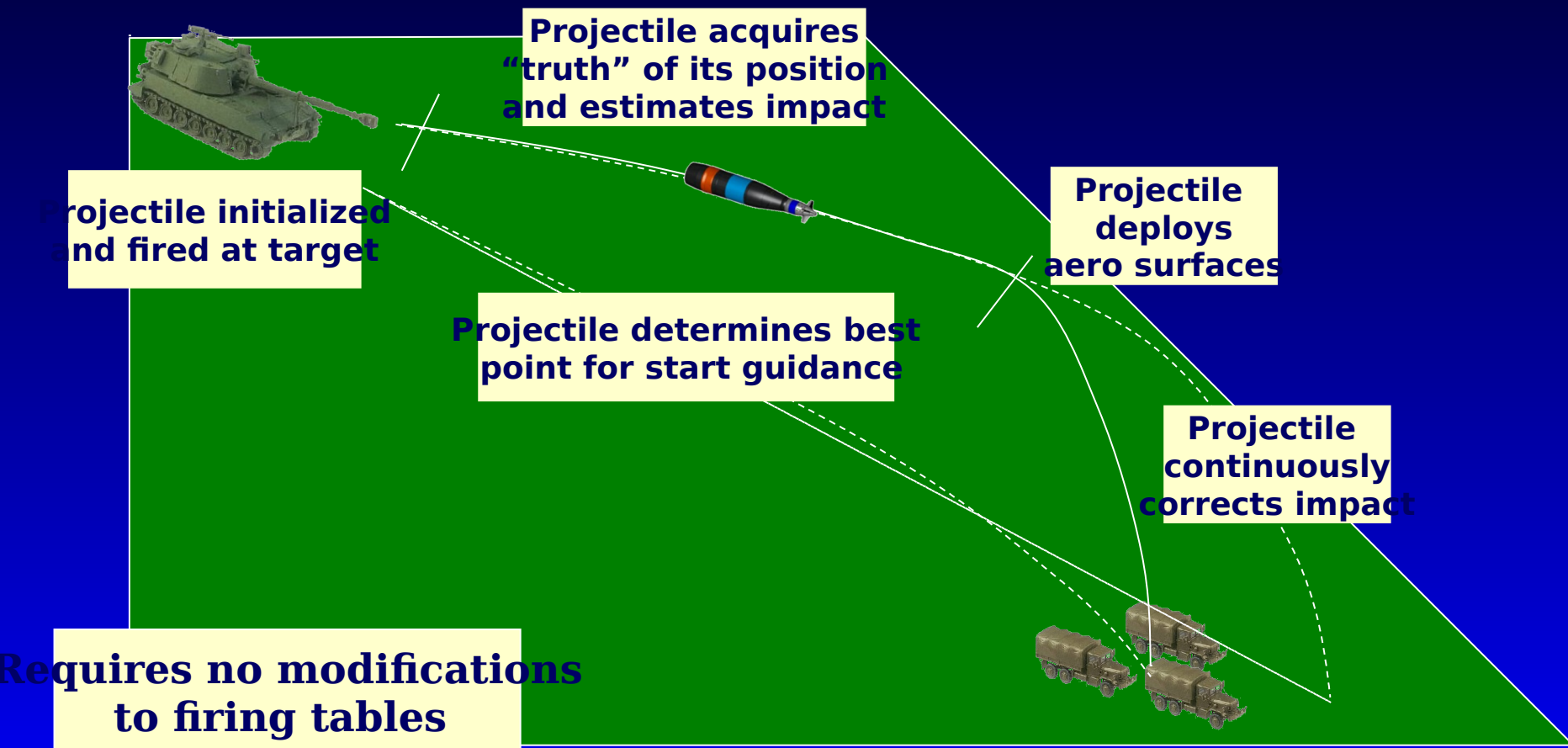
Theory of Operation - 1DOF-R

Raytheon



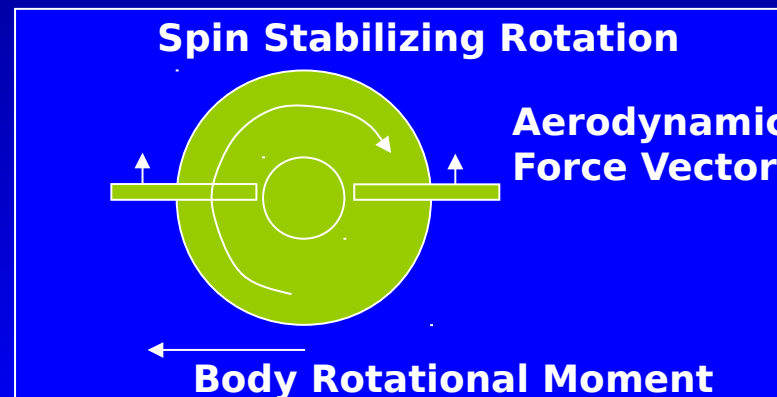
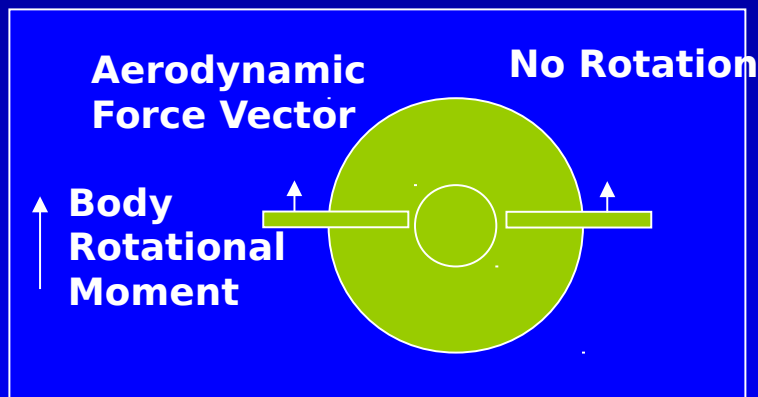
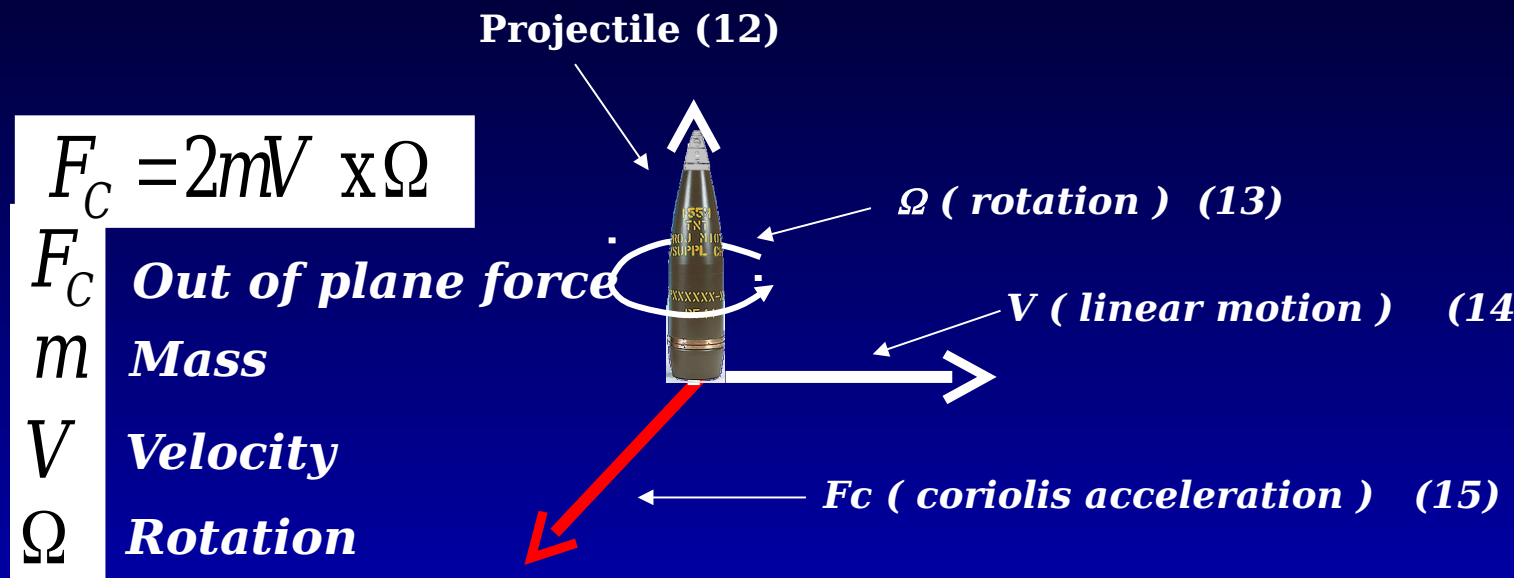
Theory of Operation - 2DOF

Raytheon



Theory of Operation - 2DOF Control

Raytheon



Potential “truth” sources for Guidance

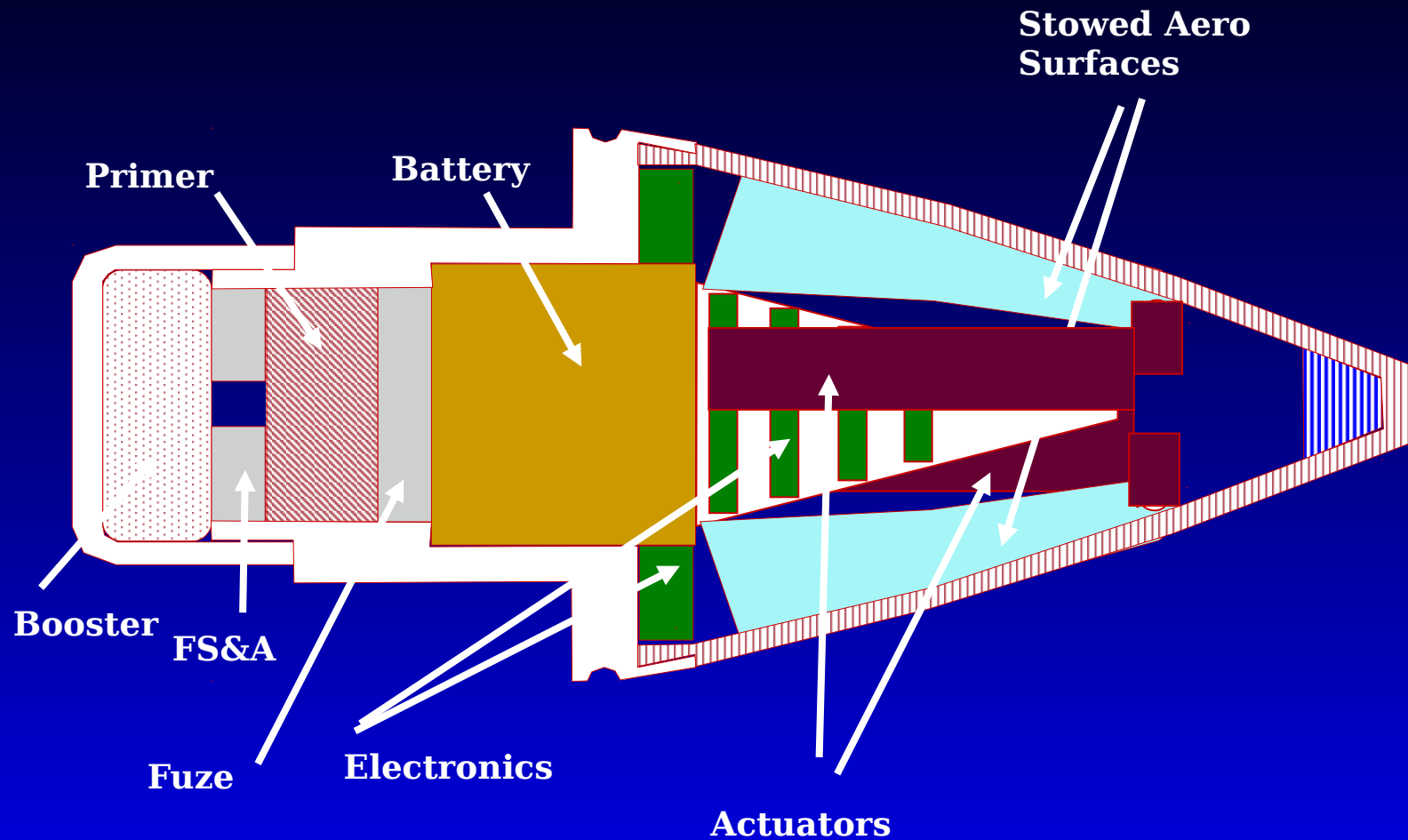
- **Ballistic**
- **Inertial**
- **Data Link Update (Command)**
- **GPS**
- **Ground Beacon Array**
- **Terminal Seeker**
 - (seeker range, packaging, costs issues)

Summary of "Truth" Sources for Guidance Raytheon

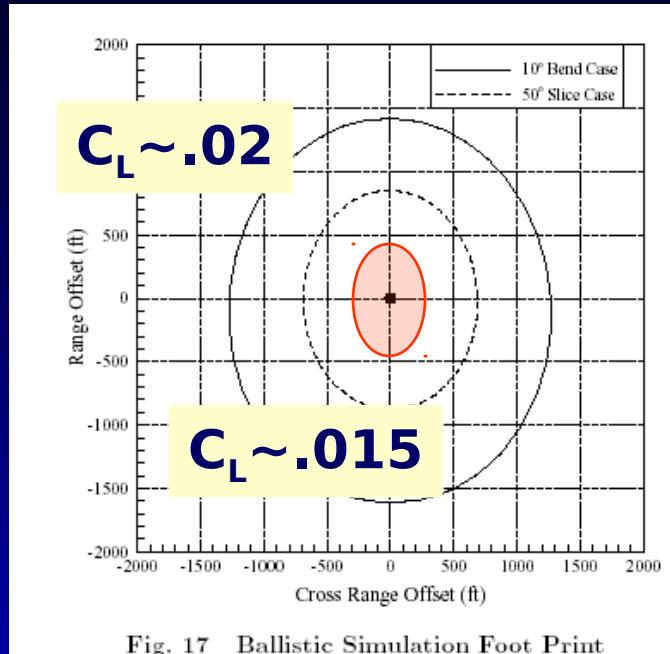
	Ballistic	Inertial	Ground Beacons	GPS / IMU	Command (PTS)	Seeker
<u>Beacon Error Sources</u>						
Maximum range LOS altitude						
Beacon siting error						
Beacon NORTHing error						
Beacon signal errors - range noise						
Beacon signal errors - angle noise						
<u>Platform error corrections</u>						
Corrects Gun- Laying angle errors						
Corrects gun NORTHing error						
Corrects Muzzle exit velocity errors						
<u>Operational Considerations</u>						
All-weather						
Sensitivity - Countermeasures						
Compatible to moving targets						
Radiating Shooter						
<u>Technical and Cost Considerations</u>						
Integration Challenges						
Unit Cost						

GPS or GPS/INS Appear to be Most Appropriate Truth

Representative 2DOF Fuze / Guidance Kit



Various Studies Have Shown Concept Feasibility

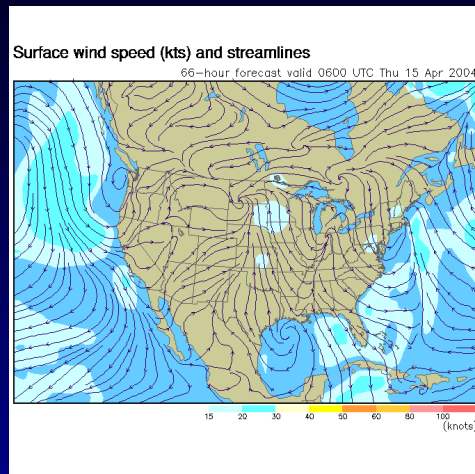


Reference -Aerodynamic Fuze Characteristics A.M. Budo
June 1998 MIT

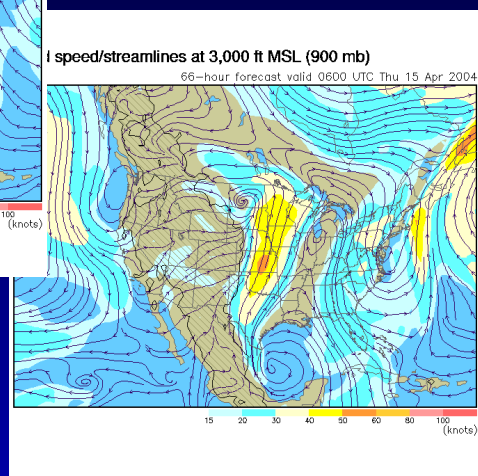
	10%	33%	67%	100%
0.25				
0.5				
1.0				
2.0				
4.0				
6.0				

- Various CCF/GIF Studies have indicated sufficient Maneuverability with Low aerodynamic effect lifts.
- However, these studies widely vary as to real life implementation fidelity (winds aloft / guidance law interaction, guidance start times, actuation constraints)
- Without considering realistic winds aloft many control concepts will appear satisfactory
- But due to physics of the spinning projectile there is a practical limit to useful C_L authority

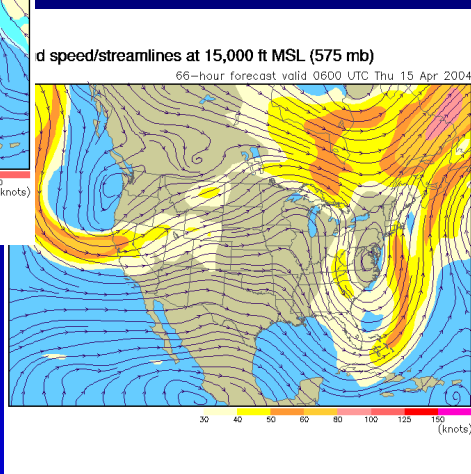
Representative Winds Aloft



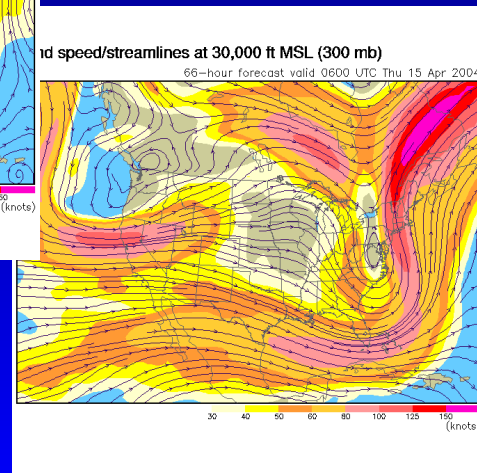
Surface



3,000 ft



12,000 ft



30,000 ft

GIF/CCF Requirements Deconstruction

NATO STANAG Compatible Concepts

1D-R 1D-D 1D+ 2D 3D 4D 5D 6D 7D

Can Correct Trajectory Dispersion

1D-R 1D-D 1D+ 2D 3D 4D 5D 6D 7D

Can Correct CEP < 50m

1D+ 2D 3D 4D 5D 6D 7D

Fuze Well Compatible

1D+ 2D 3D

Can Cost < \$5K

1D+ 2D 3D

A/J capable with no special handling

HIGH GPS AJ capable

1D+ 2D

3D

Summary

- Depending on desired Operational Flexibility and Cost Sensitivity, there are a number of potential solutions.
- Spiral development from the 1DOF (presently easily implementable) to the final desired operational product (2DOF or 3DOF) is an option
- GPS or GPS/INS are the most appropriate “truth” sources
- Joint service kit requires 2DOF or 3DOF kit at minimum
- To avoid developing new ballistic tables, nose weight/shape should conform to NATO STANAG OML
- Implementation of actuation and power source are the technical challenges